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STUDY TO DETERMINE THE EFFECTIVENESS AND COST OF A LASER-PROPELLED "LIGHTCRAFT" VEHICLE SYSTEM – RESULTS TO GUIDE FUTURE DEVELOPMENTS

Second International Symposium
on
Beamed Energy Propulsion
Sendai, Japan
20 – 23 Oct 2003

By Froning, Pike, McKinney, Mead, & Larson
Work Performed by Flight Unlimited, Flagstaff, AZ
Under the Direction of the Propulsion Directorate
Air Force Research Laboratory, Edwards AFB, CA

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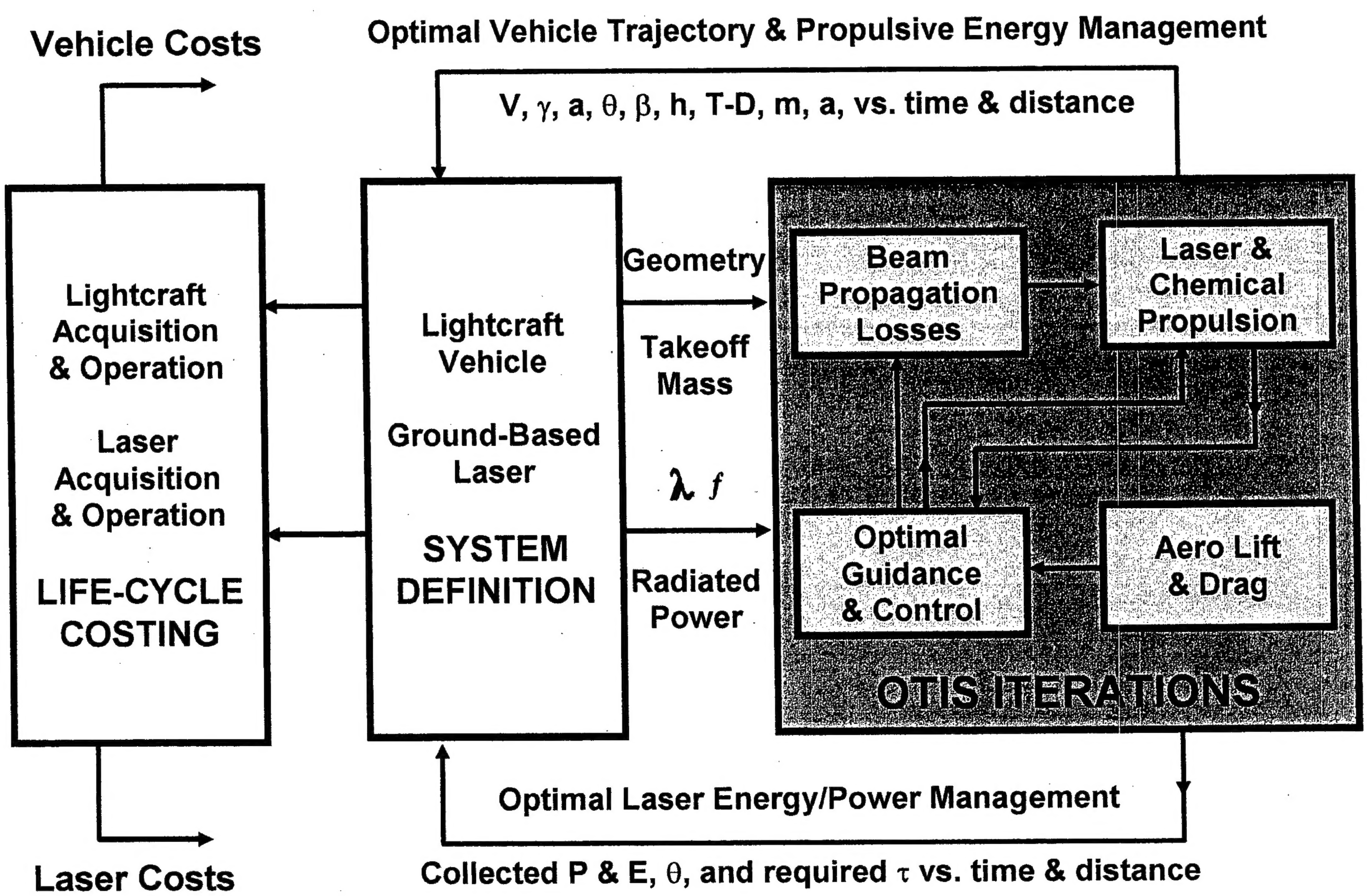
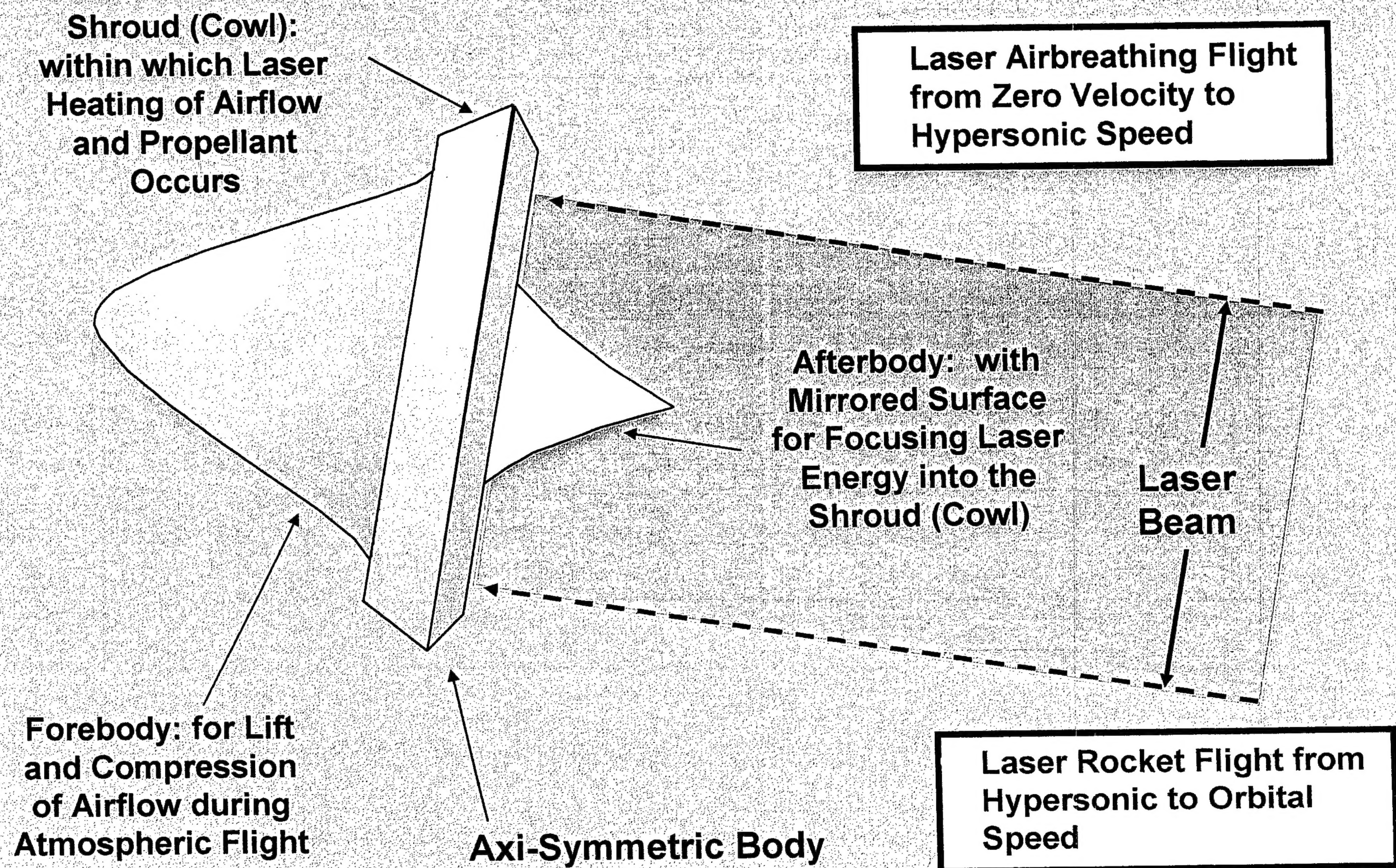
Flow Diagram of Laser Lightcraft System Study

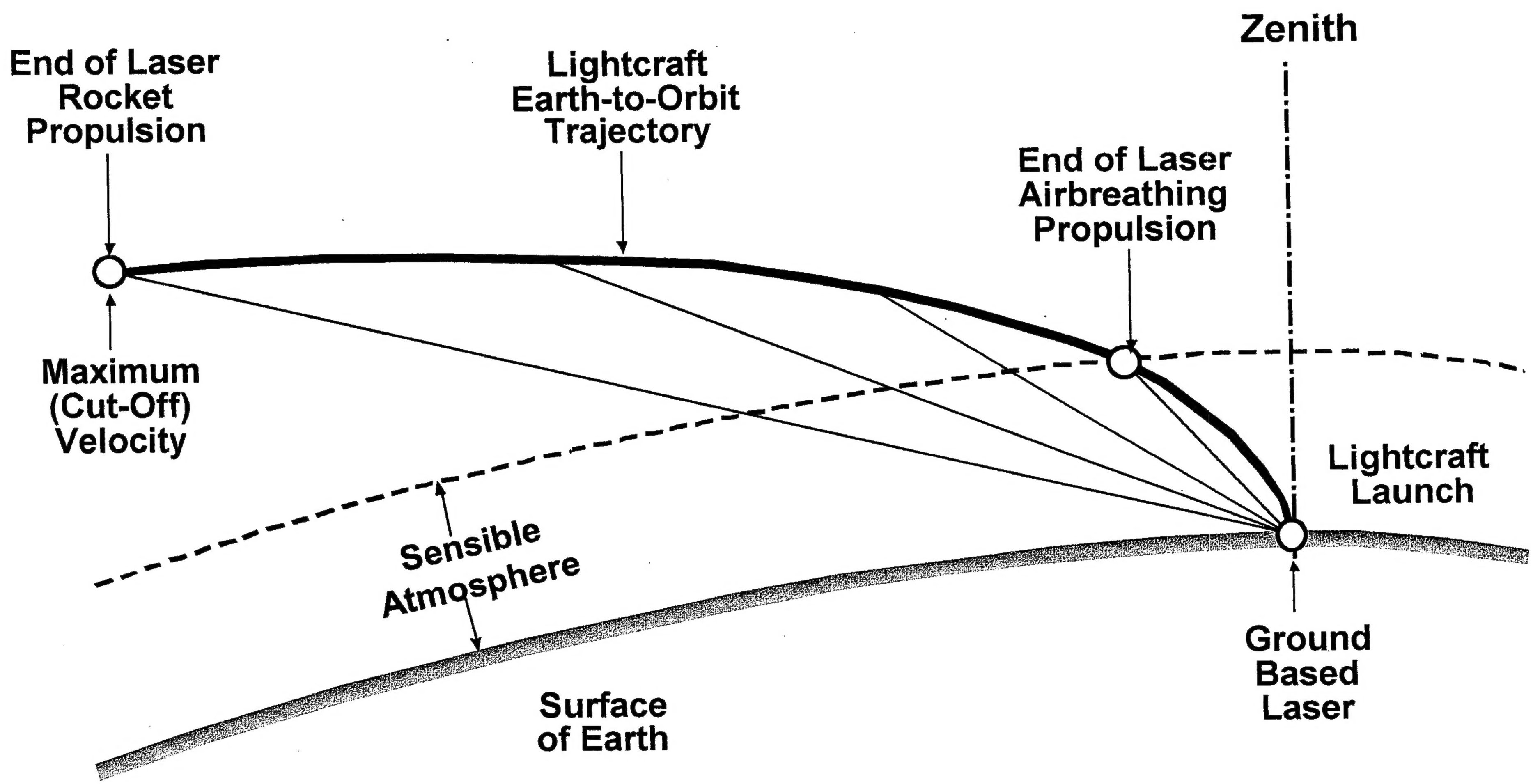


Lightcraft Vehicle Concept



Lightcraft Earth-to-Orbit Trajectory and Associated Pointing Direction of Laser Beam

(Not to Scale)



Laser Beam Power Loss Mechanisms

Diffraction:

Reduces Vacuum Propagation Intensity of Power P and wavelength λ, through an aperture of diameter D at a range of R to : $PD^2/R^2\lambda^2$

Thermal Blooming:

Laser Heating of Air Distorts Far Field Beam:

- Aggravated by low wind, low slew rate, high absorption, high power density

Turbulence:

Fluctuates Day-to-Day & Seasonally:

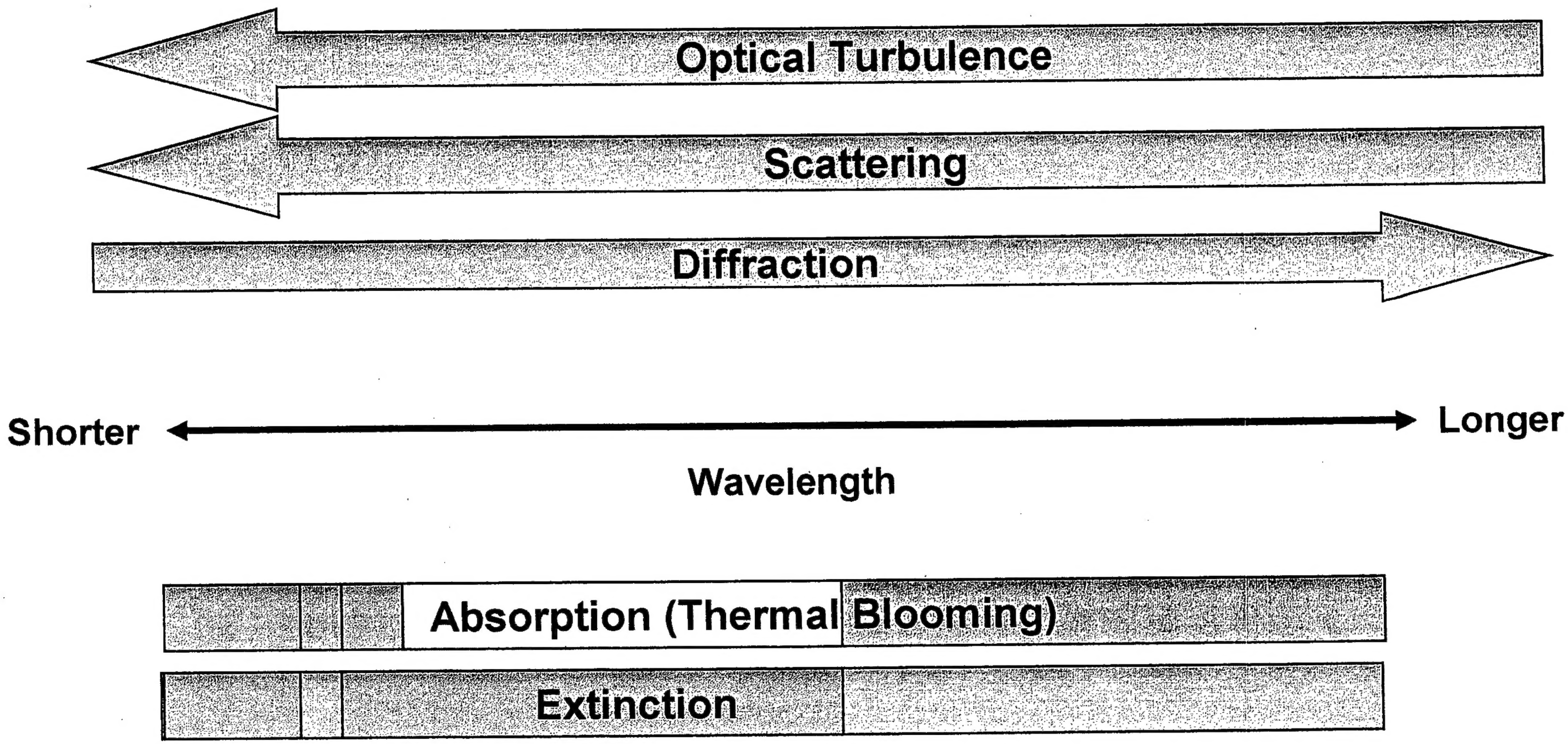
- Aggravated by low altitude targets, short wavelength, large diameter beams

Extinction:

Varies Seasonally, Daily if Fog/Rain, & by Detailed Laser Wavelength(s):

- Aggravated by higher temperature, long ranges, rain
- Devastated by fog, clouds

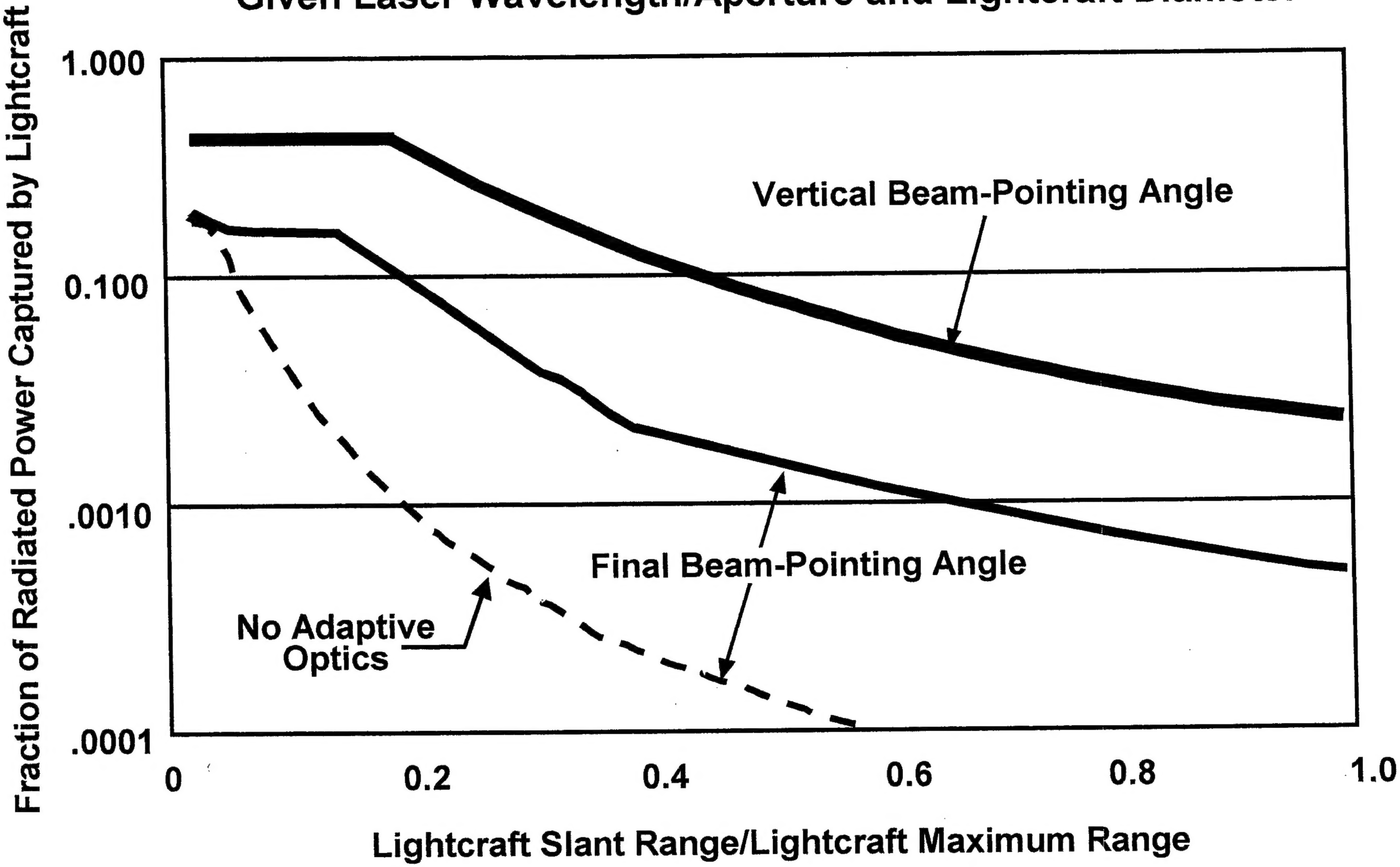
Optimization Considerations
Balancing Loss Mechanisms



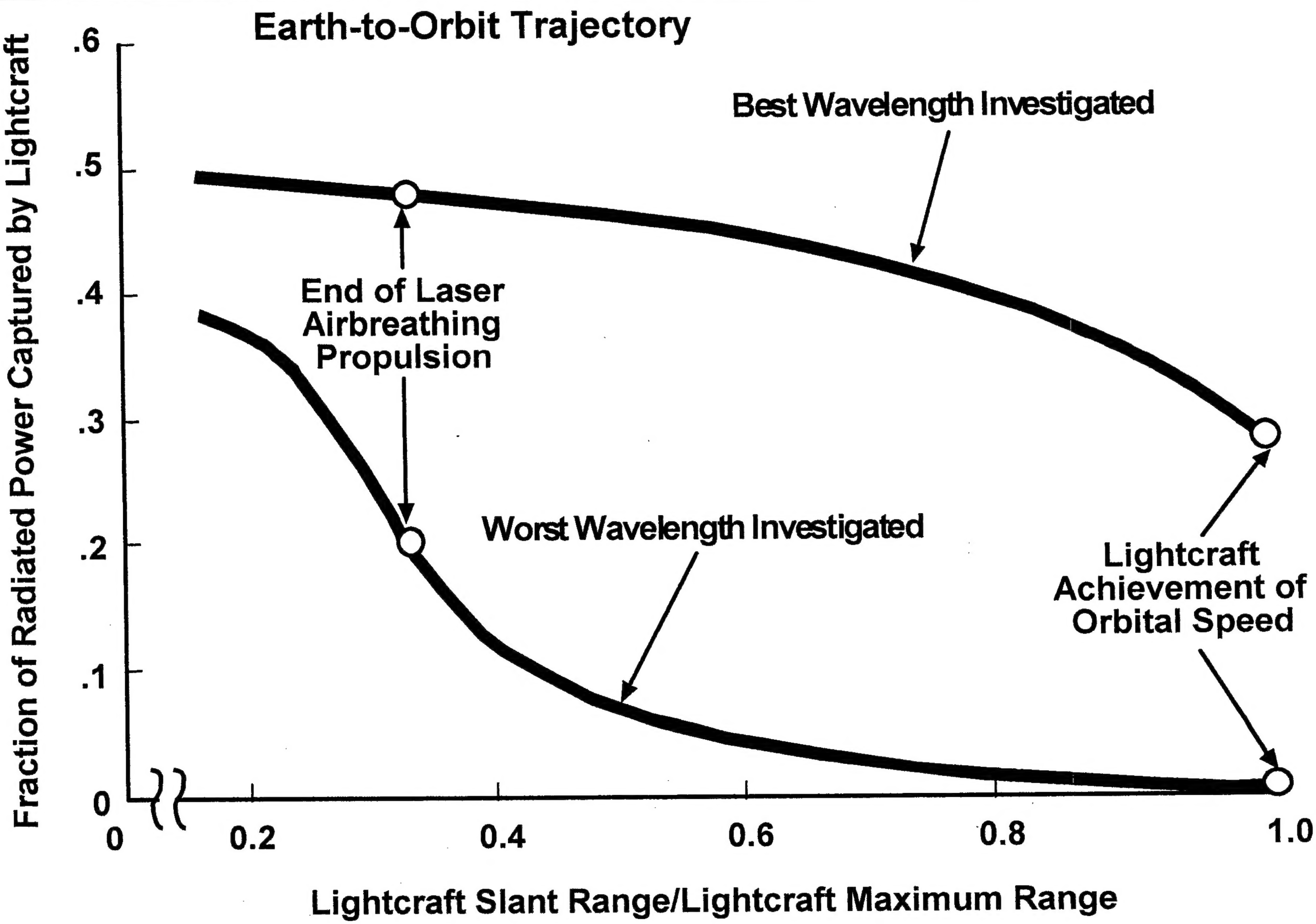
Selecting the Appropriate wavelength is a Delicate Balancing Act

Influence of Lightcraft Range and Laser Pointing Angle on Laser Power Captured by Lightcraft

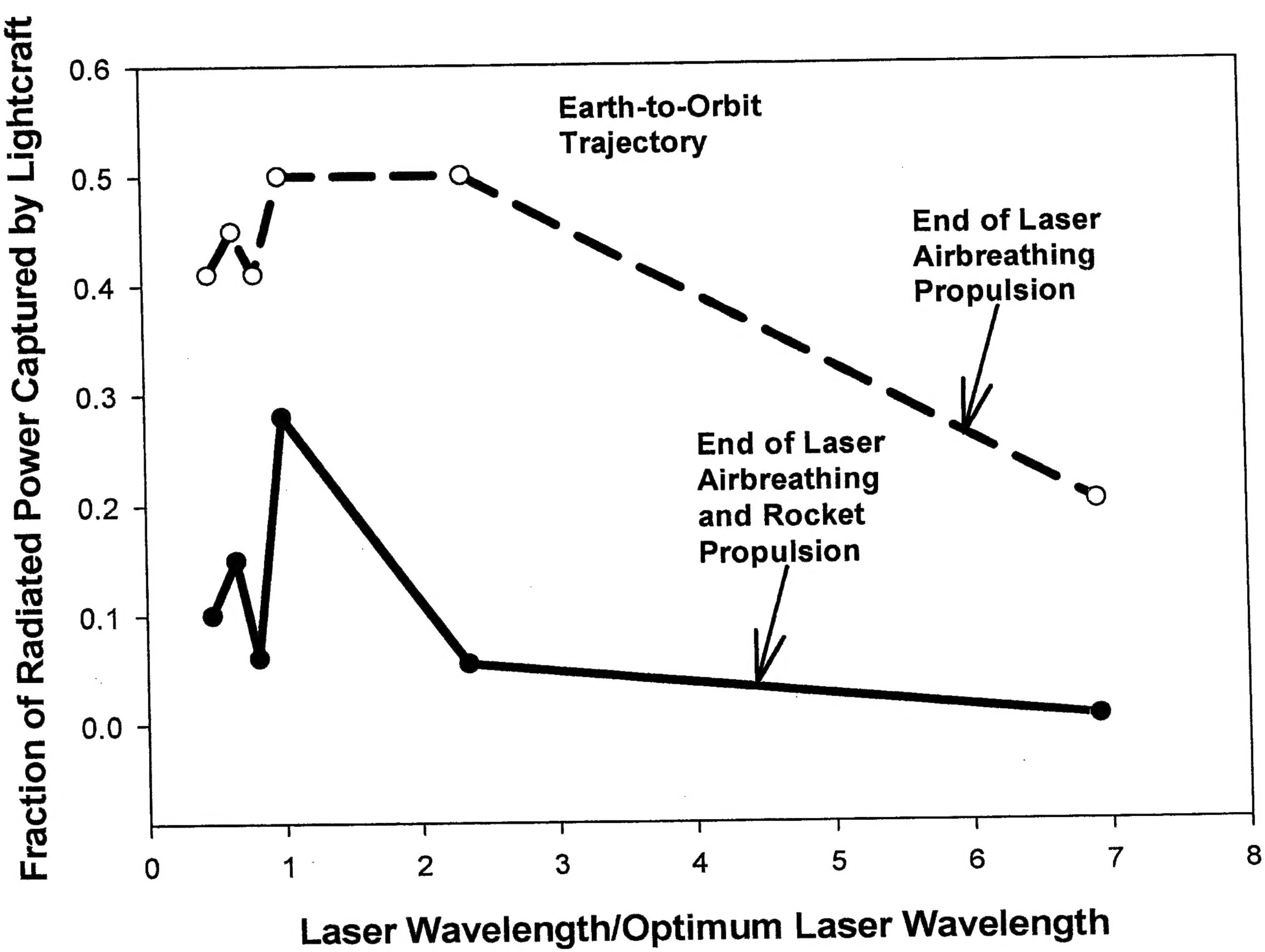
Given Laser Wavelength/Aperture and Lightcraft Diameter



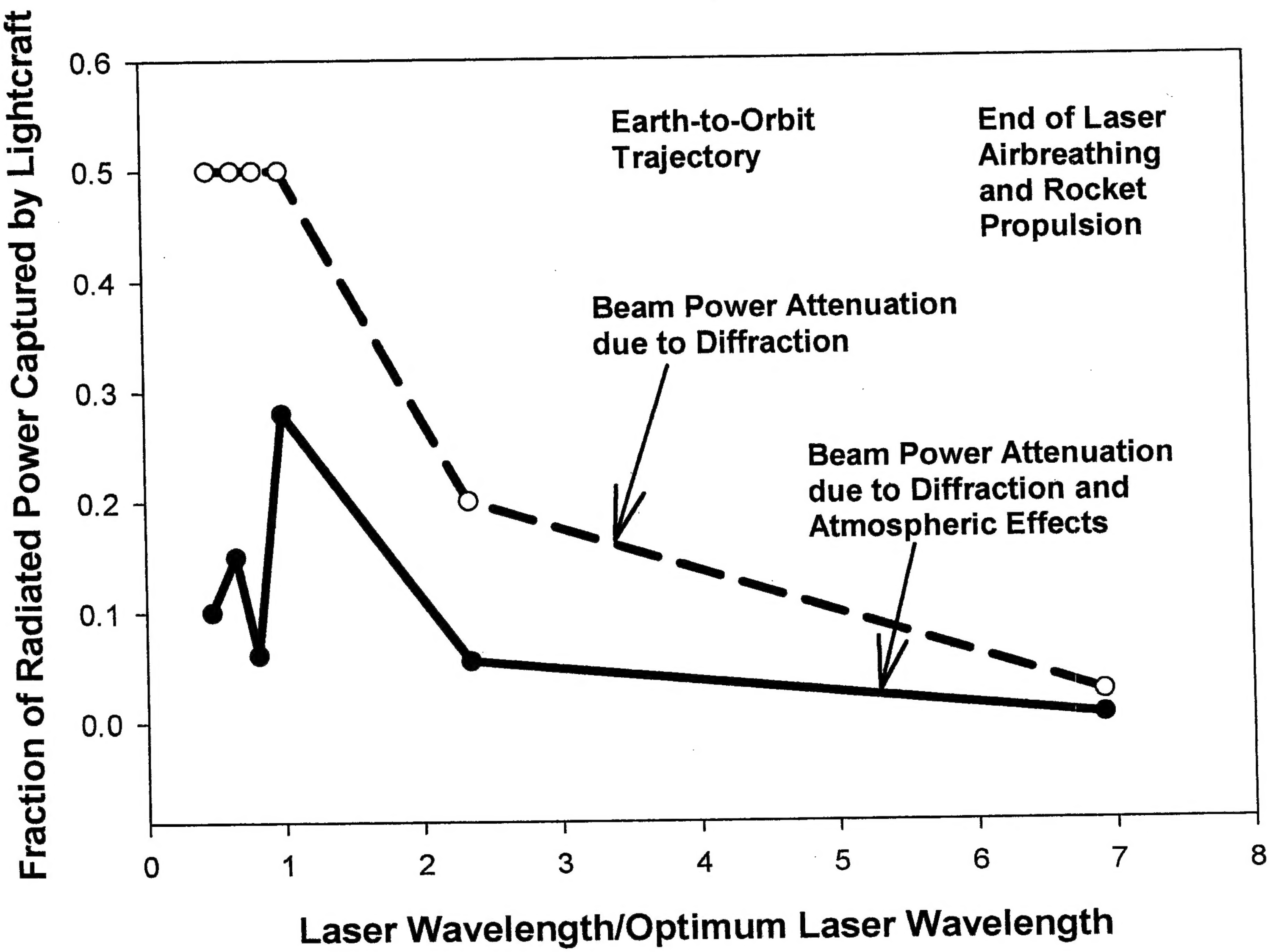
Influence on Laser Wavelength on Lightcraft Power Capture



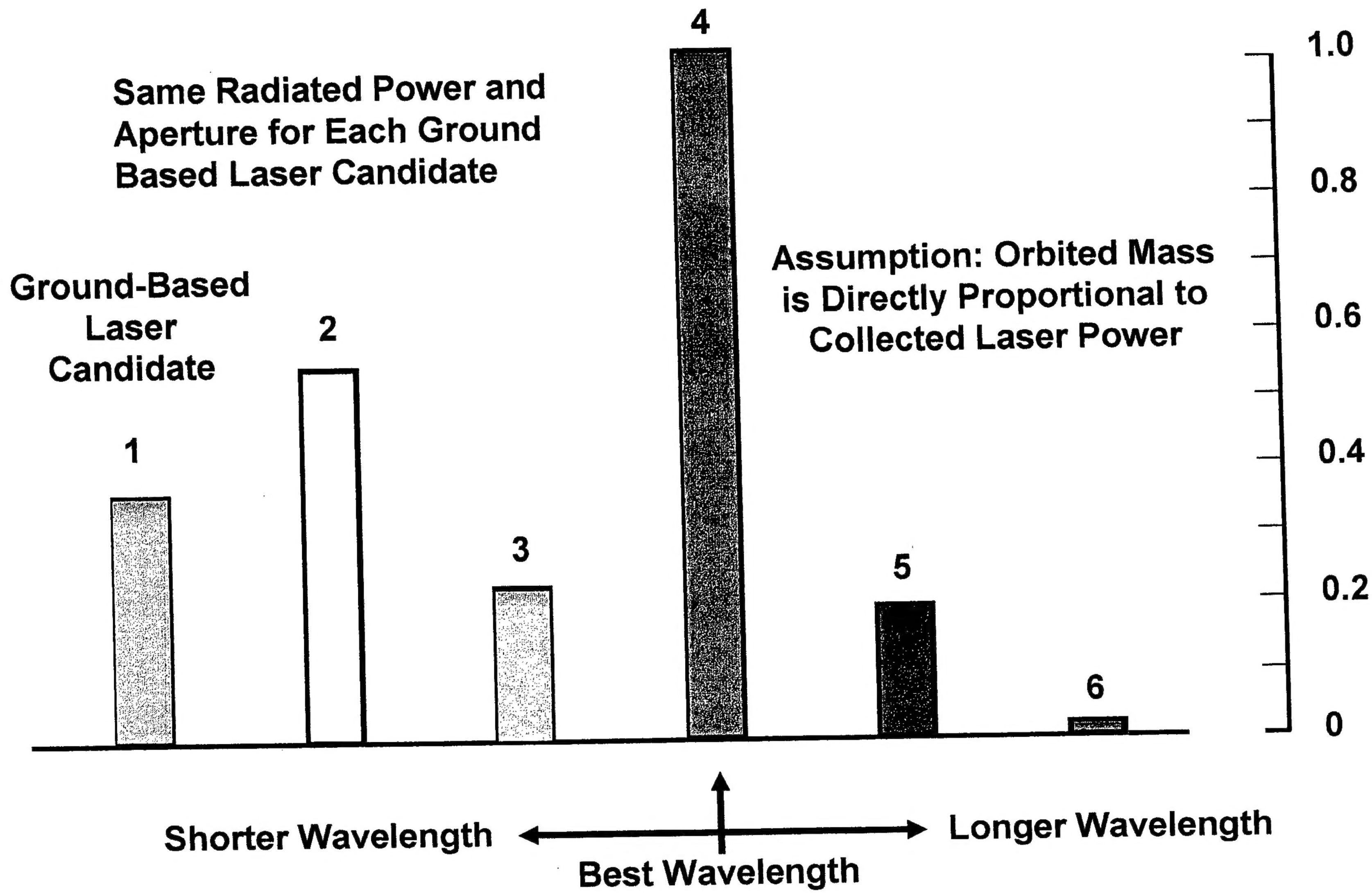
Influence of Wavelength on Lightcraft Power Captured



Influence of Wavelength on Lightcraft Power Captured



Influence of Wavelength on Orbited Mass



Summary and Conclusions

- Laser-powered lightcraft systems that deliver microsatellites to low-earth-orbit (LEO) have been studied for the Air Force Research Laboratory
- The many iterations needed for design of such an earth-to-orbit (ETO) system requires a multi-disciplinary optimizaton (MDO) for definition of the ground-based laser and lightcraft vehicle elements
- An example is the influence of laser wavelength on the energy and power lost during laser beam propagation through Earth's atmosphere and space, and the resulting effect on mass delivered by lightcraft to orbit
- Here, energy and power losses in the laser beam are very significant for ETO missions, and losses are highly dependent on laser wavelength
- Thus, wavelength (together with other laser technical, operational, and cost issues) is an important consideration in laser selection for lightcraft